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SEASONAL DEVELOPMENT IN THE GRAPE FOLLOWING FROST INJURY[1]

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The occurrence of frost injury in microclimatic (4) areas much later in the spring and earlier in the fall than seemed possible from an examination of Weather Bureau records has been noted many times by a number of investigators (1, 3, 6). Quantitative temperature and growth data have been presented for microclimatic areas of varied topography in southern Iowa which showed a close relationship between reduction in temperature in the early spring of 1942 and the degree of frost injury in the grape (1, 2).

The same relationship was evident in the investigations in the spring of 1943 but frost injury from equally low temperature at approximately the same late date (the middle of May) was much less severe (1). The difference in injury in the two seasons seemed to be attributable to differences in plant development at the time of heavy frost rather than to differences in depression of temperature and duration of the depression which were approximately the same for the two seasons.

In neither of the two seasons, was the depression in temperature at the two lower elevations on the slope of sufficient magnitude to destroy or even seriously injure the new growth, until the severe frost about the middle of May. Until this last severe frost, growth at all three stations for the two seasons was similar in rate and degree. In 1942 the growth period extended without evident injury from its initiation on April 13 to May 16 and in 1943 it extended from April 22 to May 14. Total effective heat units for this growth period were 50 per cent greater in 1942 than in 1943 and new growth at the time of frost injury in mid-May was 3 to 5 inches in 1942 and 2 inches in 1943 (1). In 1942 the grape crop was entirely destroyed at the two lower stations. The new growth at the upper station was injured but recovered sufficiently to produce approximately a full crop. In 1943 the new growth was injured at the two lower elevations but recovered with very little if any apparent reduction of yield of fruit even at the lowest elevation.

The temperature relationship studies were continued in 1944 when there was no frost injury at any of the three stations and in 1945 when frost injury was very severe. The same vineyard area (vineyards 1 and 2), on a southwest facing slope, was used in the 1944 and 1945 experiments as in the 1942 and 1943 experiments (Fig. 1). In the later experiments the difference in elevation between the upper and middle stations was 40 feet and between the middle and lower stations was 25 feet. The distance interval in each case was 300 feet. In addition to unsheltered minimum thermometers at the three stations, test thermometers were used in the vicinity of the grape buds

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to determine as nearly as possible the temperatuere to which the buds were exposed at the critical frost periods. Calibrated test thermometers, with bulbs protected by losely wrapped young grape leaves were exposed near buds at the three stations for 10 minutes at or just before daybreak on mornings when temperature was low. The minimu mtemperature readings shown in Table 1 did not vary more than 1 degree from the temperature to which the buds were exposed.

In the spring of 1945 the rate of development of new growth was much greater on the upper part of the slope than at the bottom of the slope. The difference in length of new growth at the three elevations is shown in Figure 2. This picture was taken on May 12 following the severe frost of May 9. The differences in degree of development of new growth, in minimum temperature at critical periods and in percentage of injury are given in Table 1. An examination of this table will disclose why growth was retarded at the middle and lowest levels of the slope in 1945 in contrast to the 1942 and 1943 seasons when there was practically no retardation. Following the initiation of growth in late March, there were seven periods, spaced about a week apart, when the temperature was below freezing for several hours to a day or two. In fact, the first of the buds had enlarged very little when they were killed on April 5 and later ones had enlarged to only ¾ inch and were just beginning to unfold when they were killed on April 19. Under the unfavorable growth conditions of the lowest station, there was a higher percentage of these

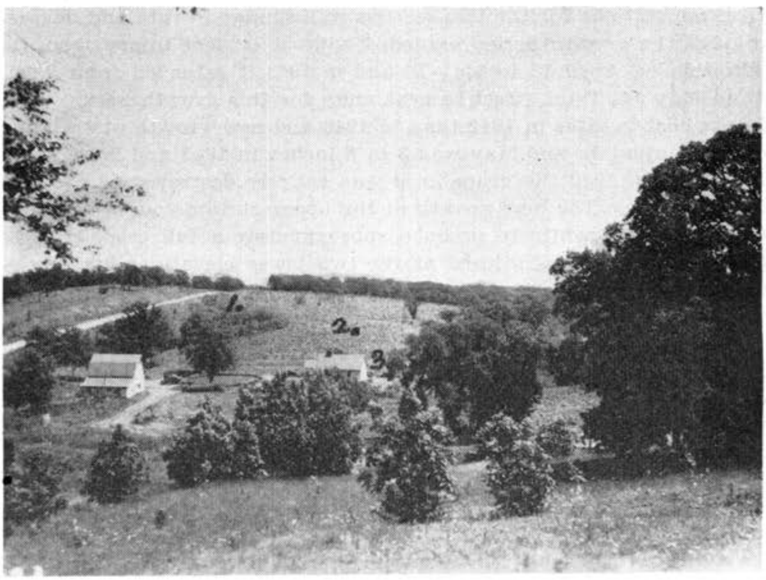

Figure 1. Distant view of experimental vineyards at the Hillculture research station, Floris, Iowa. The locations of the three microclimatic stations are numbered on the map. June. 1941.

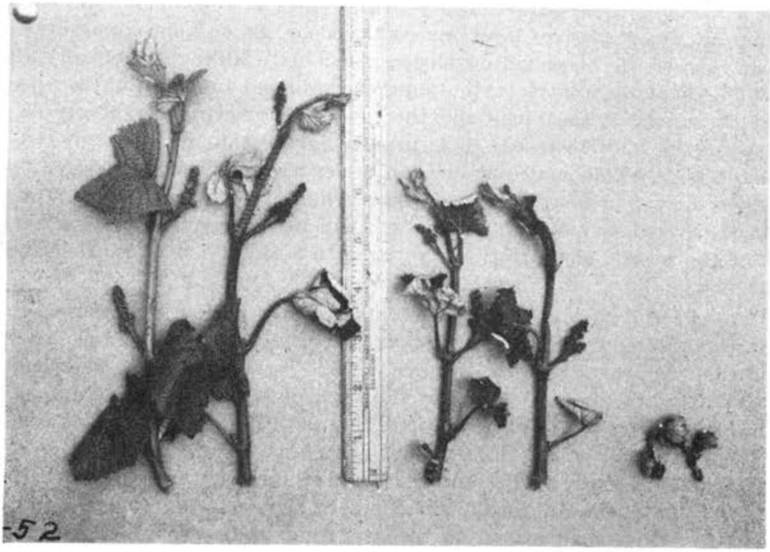

Figure 2. Degree of development and condition of new growth of Concord grape vines at the highest, middle and lowest elevations (from left to right) of a southwest facing slope following frost injury on May 9, 1945.

Table 1. Temperature readings from unsheltered minimum thermometers in degrees Fahrenheit at three elevations in vineyards 1 and 2. Growth rates and injury to grape vines on this slope are shown. Average temperature from a sheltered thermograph for each period preceding the date is also given. 1945.

	March		April					May		June
	12	22	5	12	19	27	30	9	18	4
Highest Elevation										
Minimum temperature	25	27	32	33	29	30	32	28	30	38
Ave. vine growth inches			1		1½	3		5	8	24
Percent growth killed			0	0	0	0	0	20	20	
Middle Elevation										
Minimum temperature	23	25	28	32	25	27	31	25	29	35
Ave. vine growth, inches			¾		1	2		3		16
Percent growth killed			0	0	50	0	0	50		
Lowest Elevation										
Minimum temperature	19	22	26	29	22	25	29	24	27	33
Ave. vine growth, inches			½		¾					12
Percent growth killed			40	0	60					
Ave. temp. per period										
Lowest elevation	39	53	54	61	48	49	50	48	51	64
Highest elevation	43	57	57	64	50	53	54	51	55	70

buds still dormant after the last freez on May 18 than there was at the two other stations. The percentages of dormant buds at this time which later developed, for top, middle and bottom of the slope, were approximately 5, 30 and 50.

There was more severe injury to the vines at the middle elevation than at the other two locations on the slope. Since approximately 70 per cent of the buds had developed previous to killing, practically all of the remaining buds on the vines were forced into growth because of the vigor of the vines and the favorable growing conditions following the May 18 freeze. It is usually agreed that more nearly dormant buds which may not develop under average conditions contain fewer flower primordia than do buds which develop earlier. On June 20 the average number of immature bunches of grapes per vine was 3 at the middle slope station compared to 8 at the lowest station and 20 at the upper station.

As careful a count as possible was made of injury to new growth at al lthree of the stations. This was especially difficult at the upper station. Approximately 20 per cent of the newly developed shoots at the upper station were killed by the frost of May 9 and an additional 20 per cent by the frost of May 18. It was difficult to distinguish between kill and severe injury which may have recovered, but later checks were made to determine extent of recovery.

At the highest station the development of vegetative and reproductive growth was confined to the maturing of the shoots not killed by the two frosts. There was no evidence of new buds opening and developing after May 18. This means that all food synthesis and fruiting was accomplished by the leaves and flowers present on the vines on this date. Fruit yield was equal to that on comparable sites uninjured by frost which was at least 25 per cent lower in 1945 than the average for the last 6 years. Cane growth per vine as determined by average weights of prunings of adequate samples, was 1.3 pounds per vine at this station compared to 2.5 for the middle and 2.4 for the lowest station. Because of the presence of fewer flower primordia in the late developing buds at the two lower stations, the growth balance at these two stations seemed to favor vegetative growth over differentiation, in this case the development of fruiting structures already formed in the buds. The ripening date was 10 days earlier at the upper slope station than at the two other stations.

The variation in response of the grapes at the three stations on a given slope would seem to indicate a high degree of adaptability of the grape to low temperature in the early spring in spite of the fact that the grape is more susceptible than many plants to early frost injury. The grapes at all of the stations seemed to make sufficient vegetative growth to insure adequate food reserves for the next season. The only possible exception among the three locations would be the plants at the upper station which produced a full crop and made only about half as much vegetative growth as the plants at the other stations. However there was no evidence of reduced vigor of the grapes at any of the three stations in April 1946.

The wide difference in number and time of occurence of frost periods in the spring of 1945 as compared to the three other seasons indicated that the problem of predicting seasonal variations in frost injury in grapes and other woody plants, even in the same microclimatic area, is not a simple one. Moreover, although the three earlier seasons resembled one another in the absence of frost periods during the early development of the grape, they varied so widely in other respects that the response of the grape was widely different each season. The results of these and other studies on frost injury indicate that the solution of such research problems must be based on experimental evidence of variations in seasons, in microclimatic areas and in growth response not only of the species of plant but of the particular variety and selection of the plant used.

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